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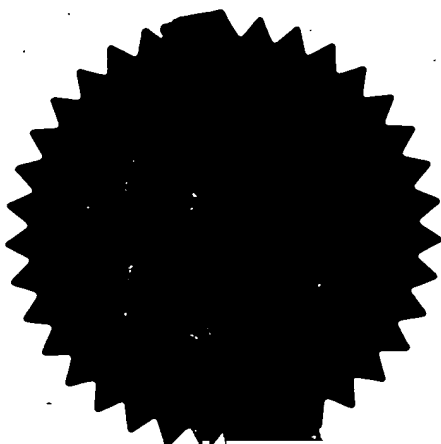
ORIGINALITY DOCUMENT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

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Signed

*W. Evans*

Dated

29 December 2000

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# 4

Atty. Dkt. No. 085874/0294

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Applicant: Nicholas P. R. HILL  
Title: CONTACT SENSITIVE DEVICE  
Appl. No.: 09/746,405  
Filing Date: 12/26/2000  
Examiner: Unassigned  
Art Unit: 2856

**CLAIM FOR CONVENTION PRIORITY**

Commissioner for Patents  
Washington, D.C. 20231

Sir:


The benefit of the filing date of the following prior foreign application filed in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed.

In support of this claim, filed herewith is a certified copy of said original foreign application:

- United Kingdom Patent Application No. 9930404.0 filed December 23, 1999; and
- United Kingdom Patent Application No. 0025771.7 filed October 20, 2000.

Respectfully submitted,

Date **FEB 28 2001**

By 

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Patents Act 1977  
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23 DEC 1999

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P01/7700 0.00-9930404.0  
The Patent Office

## Request for grant of a patent

(See the notes on the back of this form. You can also get  
an explanatory leaflet from the Patent Office to help you  
fill in this form).Cardiff Road  
Newport  
Gwent NP9 1RH

1. Your Reference

P.6365.GBA

23 DEC 1999

9930404.0

2. Patent application number

(The Patent Office will fill in this part)

3. Full name, address and postcode of the or of  
each applicant (underline all surnames)

New Transducers Limited

Ixworth House  
37 Ixworth Place  
London  
SW3 3QH

7283476002

Patents ADP number (if you know it)

If the applicant is a corporate body, give the  
country/state of its incorporation

G.B.

4. Title of the invention

Touch Sensor

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom  
to which all correspondence should be sent  
(including the postcode)MAGUIRE BOSS  
5 Crown Street  
St. Ives  
Cambridgeshire  
PE17 4EB

Patents ADP number (if you know it)

07188725001

6. If you are declaring priority from one or more  
earlier patent applications, give the country  
and the date of filing of the or of each of these  
earlier applications and (if you know it) the or  
each application number

Country

Priority application number  
(if you know it)Date of filing  
(day/month/year)7. If this application is divided or otherwise  
derived from an earlier UK application,  
give the number and the filing date of  
the earlier application

Number of earlier application

Date of filing  
(day/month/year)8. Is a statement of inventorship and of right  
to grant of a patent required in support of  
this request? (Answer 'Yes' if:

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an  
applicant, or
  - c) any named applicant is a corporate body:)
- See note (d)

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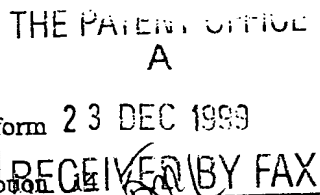
Continuation sheets of this form 23 DEC 1999

Description

Claims(s)

Abstract

Drawing(s)



10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

Date 23/12/99

MAGUIRE BOSS

12. Name and daytime telephone number of person to contact in the United Kingdom

Peter Maguire

Tel: 01480 301588

**Warning**

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- c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
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**Patents Form 1/77**

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TITLE: TOUCH SENSOR

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DESCRIPTION

15       The invention relates to touch sensors.

Visual displays often include some form of touch sensitive screen. This is becoming more common with the emergence of the next generation of portable multimedia devices such as palm top computers. It has now been suggested to make use of the available screen area as a bending wave acoustic device and to achieve good quality sound within tight spatial and weight constraints.

25       It is the object of this invention to use the bending wave vibration of an acoustic device, e.g. a display screen as a touch sensor.

Such a device may have the following advantages:-

- 1) to enable a display screen acoustic device to be implemented in an application where a touch sensitive  
5 capability is also required;
- 2) to provide a more versatile technology than current touch screen technologies, being sensitive not only to location of the touch but also pressure;
- 10 3) to provide a cheaper form of touch sensitive screen than current implementations, which require an array of transparent contacts or a complex sensor of a magnetic tip etc, and
- 15 4) to be readily scaleable in size and spatial sensitivity by control of the material parameters of the active bending wave element.

20 According to the invention, a plate capable of supporting bending waves as an acoustic device is also capable of relaying information regarding mechanical disturbances in the body of the plate to the edge of the plate. Therefore a plate similar to those used as acoustic  
25 devices can also be used to act as a touch sensitive device.

The invention describes such a device both in active



and passive embodiments.

In a passive sensor an impulse in the body of the plate will start a bending wave towards the edge of the 5 plate. This is detected by a set of sensing transducers around the edge and the signals analysed to determine the spatial origin and force profile of the applied impulse. The most simple form of analysis is as follows:

10 1) the impulse is detected at each transducer at a specific time,

2) the ratio of times at each sensor gives the ratio of distances of each sensor from the origin of the impulse,  
15 and

3) these distances are intersected to give the position of the impulse.

20 The above method allows the determination of the impulse position with a minimum of three sensors, the accuracy of the calculation increasing with extra sensors.

More sophisticated processing can provide further  
25 information concerning the initial impulse, particularly when used together with a knowledge of the material parameters. For example, a measurement of the frequency content of the measured signal can be used to infer the

profile of the initial impulse.

The advantages of passive sensing include:-

- 5 1) the method is broadband, and therefore includes the complete frequency content required to image the impulse shape, and
- 2) as the method is passive the power requirements are 10 minimal.

Disadvantages of passive sensing are that:-

- 1) the frequency content of the measured signal is 15 limited by the frequency content of the impulse. Consequently the high frequency information is limited, which translates into a relatively long bending wavelength. The spatial resolution of the signal is therefore limited;
- 20 2) the measured signal is susceptible to external noise. This includes an audio signal applied to the panel, as is the case for a visual display/acoustic panel application. The drawback is therefore that it will prove problematic to isolate the impulse when the panel is used as a 25 loudspeaker, limiting the end result to separate loudspeaker or touch screen operation, and
- 3) the method is insensitive to the movement of a finger

or pen on the panel, once it has made contact, since this movement produces no strong impulse.

In an active sensor, the location of the contact is sensed from the response of the plate to an external stimulus. One transducer excites bending waves in the plate and one or more sensing transducers measure the response. The difference between the response with and without an external contact can be used to determine its location. This can be done in a number of ways, two of which are illustrated.

Firstly, the time response of the panel can either be directly measured or inferred from a frequency domain analysis. The difference between the response with and without the contact can be used to isolate reflections emanating from the contact position. If these reflections are sensed at multiple points the relative arrival times around the plate can be used to infer the location of the contact in the plane, in a similar manner to the method described for passive sensing.

Secondly, the steady state response can be measured before and after the contact. The different response contains information as to the location of the contact. However, due to the complex nature of the motion in the plane the location of the contact can not be readily inferred from this response. One possible solution to this

problem is apply a neural net method to the data and train the algorithm to correctly recognise the signature of each location in the plane. This accuracy of this approach may be improved by repeating the method at multiple frequencies of excitation.

An important issue to address when considering these approaches is that the external signal should not be acoustically obvious. Methods to avoid this include making the signal very small in amplitude or making it noise-like. The latter makes any audible signal less obvious, while a particular correlation may be hidden in the noise that the calculation is able to latch on to. An alternative is to make the signal inaudible by increasing the frequency above 20kHz. This has the advantage that a large signal amplitude can be used and the high frequency translates into a high spatial resolution.

Advantages of active sensing include:-

20

1) as the technique measures the response to an external signal, high frequency information is not limited and a high spatial resolution is possible;

25 2) the technique is sensitive to the position of a contact even when there is no strong impulse. On example of such a situation is the movement of a pen or finger on the plate without its removal from the plate, and

3) the susceptibility to external noise can be greatly reduced. This can be achieved by sensing the response in a frequency band where the external noise is small, such as 5 above the audible spectrum. An alternative is to give the signal a particular correlation, enabling its detection even when small compared to the background noise.

Disadvantages of active sensing include:-

10

1) the technique is likely to be less sensitive to the profile of the impulse than the passive scheme. However, more sophisticated processing may improve this situation. For example, the greater the pressure of a finger or pen 15 the larger the degree of extra damping likely to be introduced. This may be identified by a relative simple extra processing of the data, and

2) the need for an external signal is likely to require 20 more power than the passive measurement. This drawback can be minimised by making the exciting signal as small as possible. Also, when the exciting signal is at high frequency piezo transducers may be employed, which have the advantage of a very high efficiency.

25

The two techniques described above have specific advantages and disadvantages. The passive technique is particularly sensitive to the impulse shape, whereas the

active technique affords a high spatial resolution. Therefore a combination of the two techniques might prove the most appropriate approach. Firstly, the active approach isolates the position and time of the contact.

5 Linear prediction can be used to estimate the noise signal over this time interval, which is then removed from the measured data. The remaining signal approximates the passive response of the plate to the impulse, which may then be used to estimate its pressure profile.

10

It has already been stated that the minimum number of transducers required to spatially resolve the location of the contact to the plate is three, with the accuracy of the localisation increasing with the number of transducers.

15 The transducer placement will be subject to the specific topology of the application, but it is likely that a relatively equal spacing around the edge of the plate will give good results.

20 One possible topology makes use of the audio transducers already in place as sensing and/or emitting transducers. This implementation adds the facility for a touch screen with the minimum of extra hardware. However, if this approach is not possible then small piezo elements  
25 might prove the most suitable transducers, as these are particularly suited to the ultrasonic frequencies required for the active sensing.

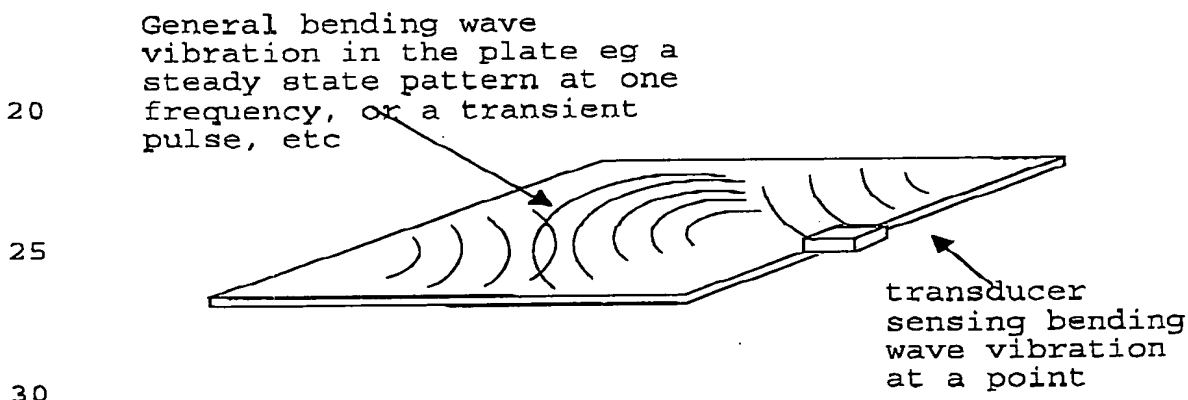
The concept has been described in terms of a transparent plate used in a visual display/acoustic device application. However, the technique may be extended to any plate such as a non-transparent one with a printed pattern. In addition, the method should not be limited to bending wave vibrations, since any excitations capable of relaying mechanical information from the body of the panel to the edge are equally relevant. Examples of such excitations include elastic and shear vibrations.

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The invention is diagrammatically illustrated in the following.

Illustration of the general principle of a touch sensor using bending wave vibration as the active sensing element

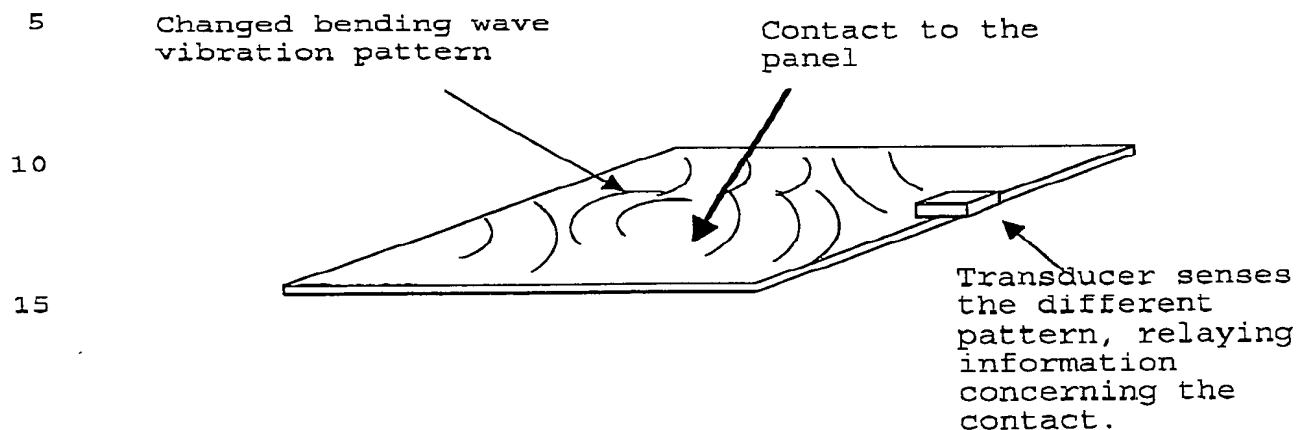
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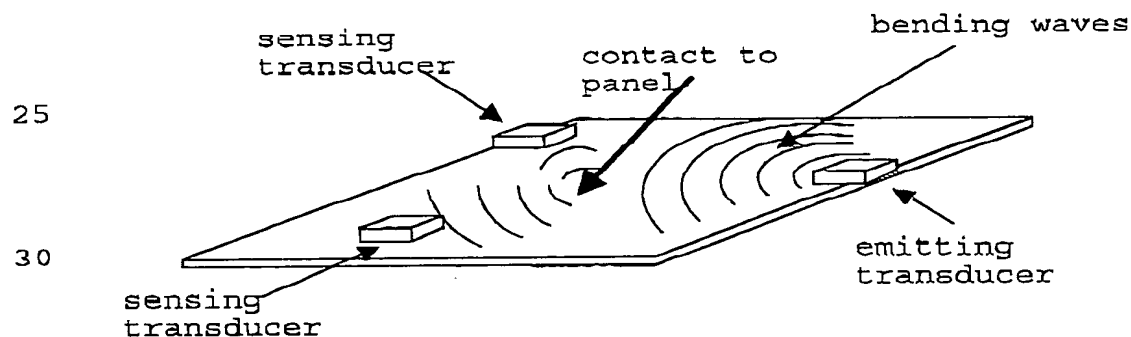
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A contact to the plate changes the bending wave pattern. Note this can be either by disturbing the path of bending waves already in the panel, or can be by generation of new bending waves, emanating from the contact point. The

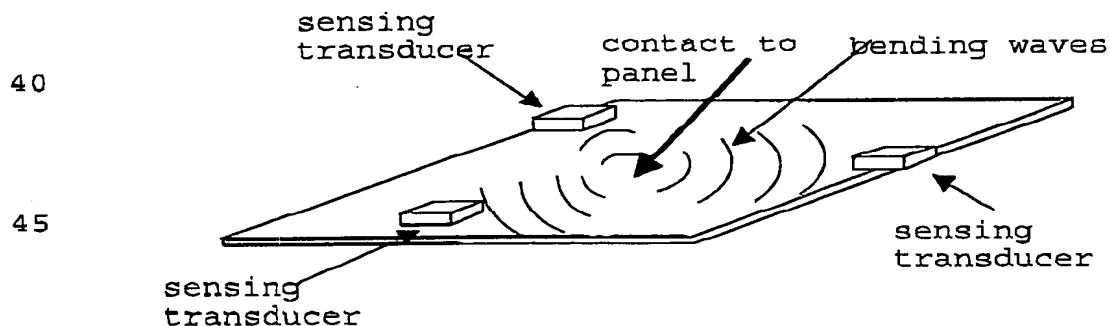
change in bending wave pattern can be sensed by a sensing transducer, relaying information concerning the location and pressure profile of the contact.



20 Illustration of a possible active touch sensor.



35 Illustration of a possible passive touch sensor.





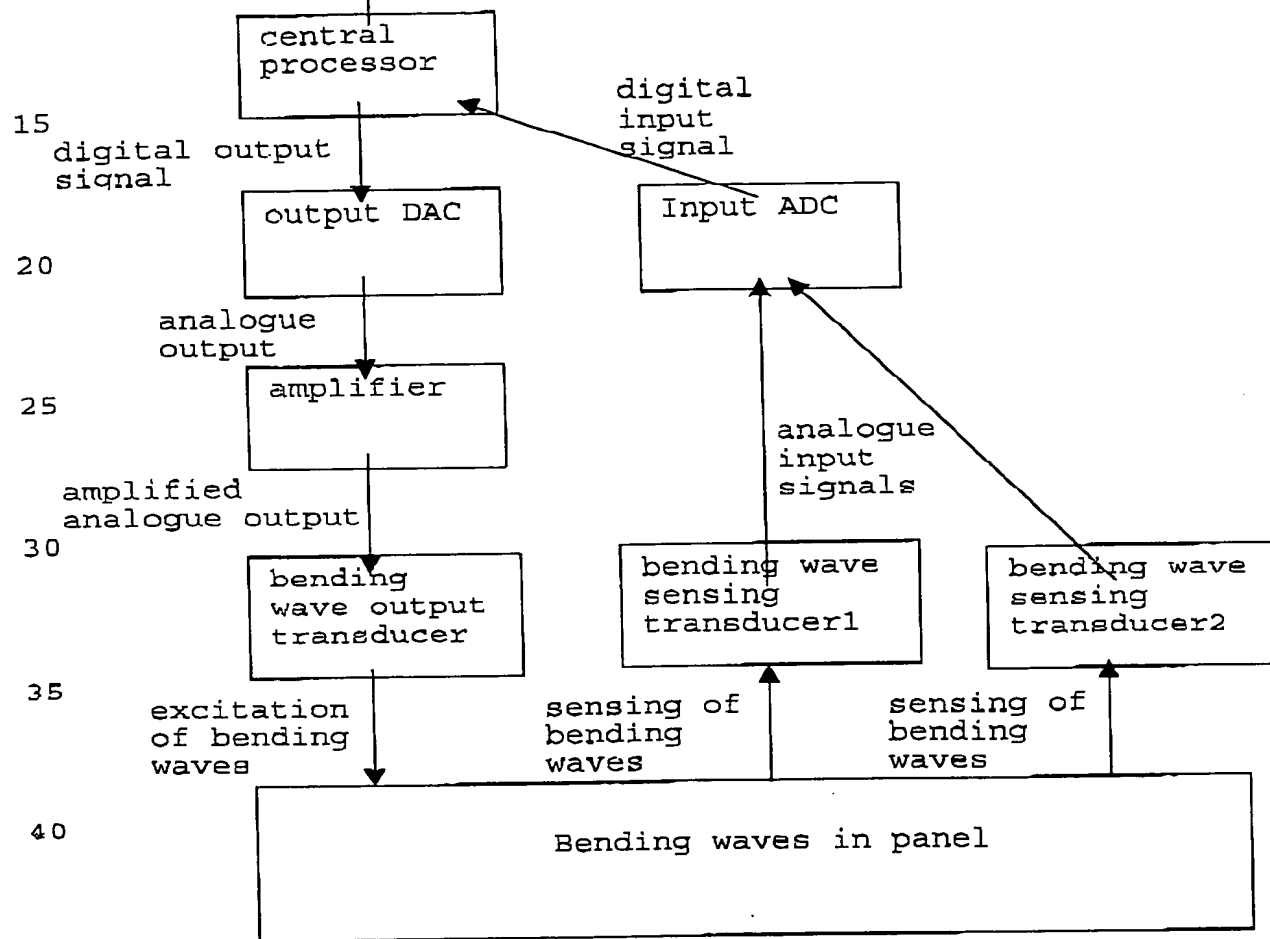
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# Block diagram of a possible implementation topology

Information detailing the location and profile of the impulse. Examples include:

- 1) The x,y coordinates of the contact.
- 2) The characteristic size of the contact, eg 1mm corresponds to a pen or stylus, 1cm corresponds to a finger.
- 3) Profile of pressure of contact as a function of time.

10

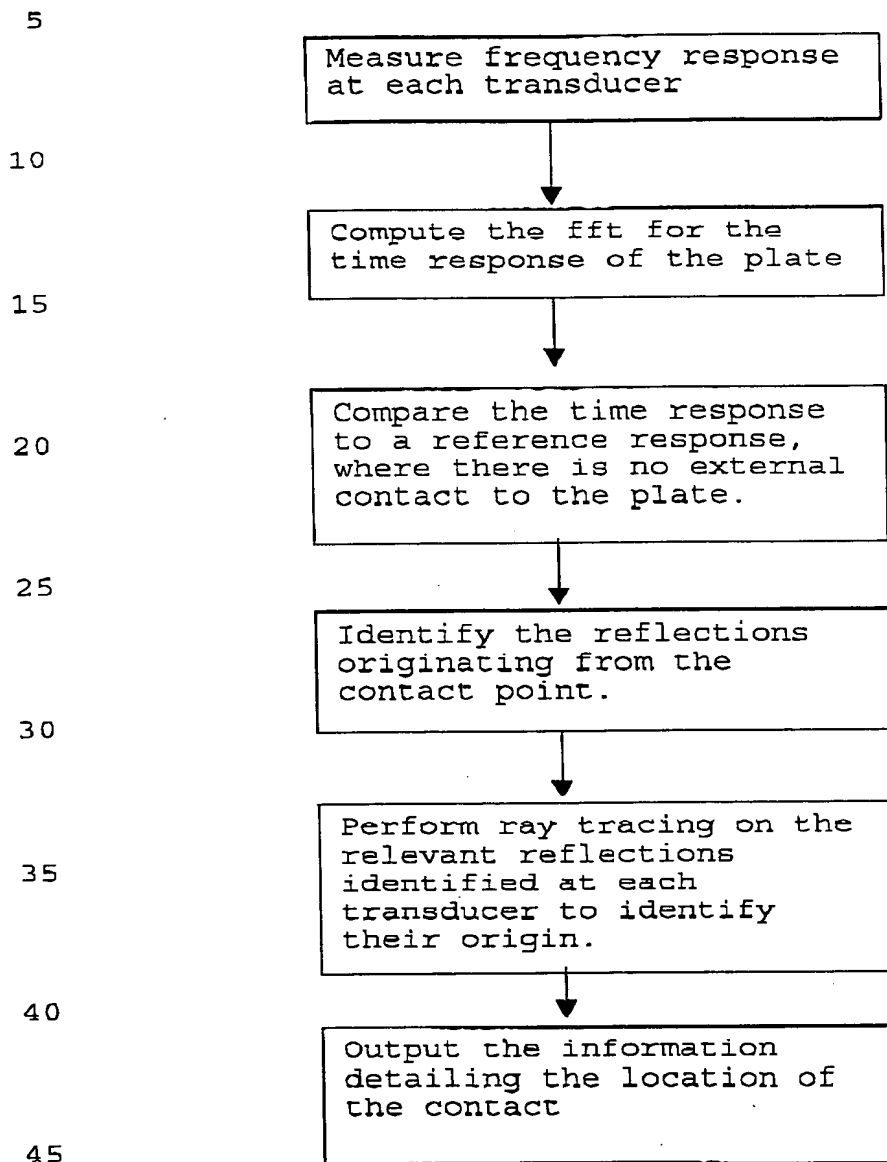


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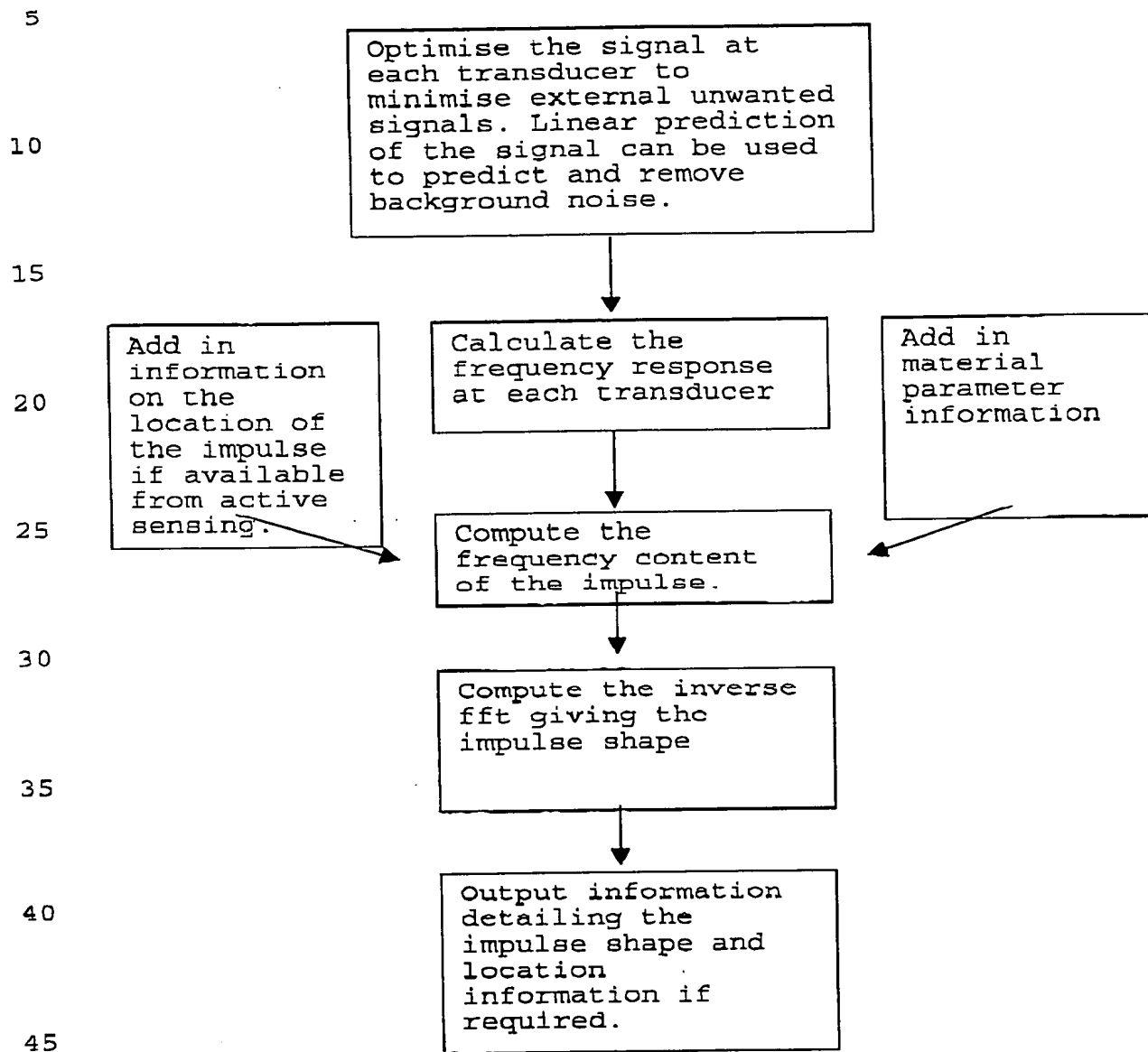
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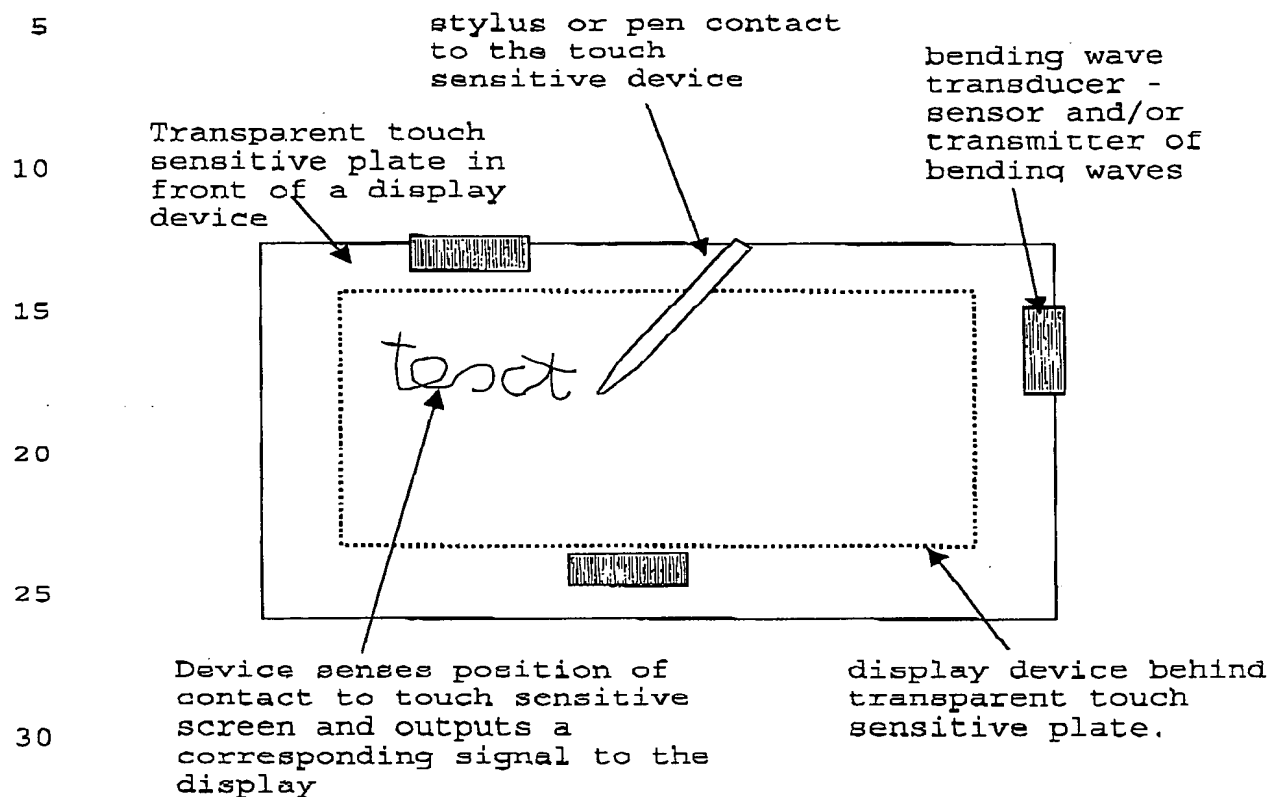
Block diagram of a possible processing algorithm for active sensing in the time domain



Block diagram of a possible processing algorithm for passive sensing



# Illustration of a possible touch screen implementation



35 The invention thus provides a novel and advantageous touch sensor, and touch sensor combined with a bending wave panel acoustic device.

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